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Proposed Registration Decision PRD2011-08

Carfentrazone-ethyl

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Overview

Proposed Registration Decision for Carfentrazone-ethyl and Quicksilver Herbicide

Health Canada's Pest Management Regulatory Agency (PMRA), under the authority of the *Pest Control Products Act* and Regulations, is proposing full registration for the sale and use of Aim (Carfentrazone-ethyl) Technical Herbicide and Quicksilver Herbicide, containing the technical grade active ingredient carfentrazone-ethyl, to control silvery-thread moss in golf course greens and tees.

An evaluation of available scientific information found that, under the approved conditions of use, the product has value and does not present an unacceptable risk to human health or the environment.

This Overview describes the key points of the evaluation, while the Science Evaluation provides detailed technical information on the human health, environmental and value assessments of Aim (Carfentrazone-ethyl) Technical Herbicide and Quicksilver Herbicide.

What Does Health Canada Consider When Making a Registration Decision?

The key objective of the *Pest Control Products Act* is to prevent unacceptable risks to people and the environment from the use of pest control products. Health or environmental risk is considered acceptable[1] if there is reasonable certainty that no harm to human health, future generations or the environment will result from use or exposure to the product under its proposed conditions of registration. The Act also requires that products have value[2] when used according to the label directions. Conditions of registration may include special precautionary measures on the product label to further reduce risk.

To reach its decisions, the PMRA applies modern, rigorous risk-assessment methods and policies. These methods consider the unique characteristics of sensitive subpopulations in humans (e.g. children) as well as organisms in the environment (e.g. those most sensitive to environmental contaminants). These methods and policies also consider the nature of the effects observed and the uncertainties when predicting the impact of pesticides. For more information on how the PMRA regulates pesticides, the assessment process and risk-reduction programs, please visit the Pesticides and Pest Management Portion of Health Canada's website at healthcanada.gc.ca/pmra.

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1 "Acceptable risks" as defined by subsection 2(2) of the *Pest Control Products Act*.

2 "Value" as defined by subsection 2(1) of the *Pest Control Products Act*: "the product's actual or potential contribution to pest management, taking into account its conditions or proposed conditions of registration, and includes the product's (*a*) efficacy; (*b*) effect on host organisms in connection with which it is intended to be used; and (*c*) health, safety and environmental benefits and social and economic impact."

Before making a final registration decision on carfentrazone-ethyl, the PMRA will consider all comments received from the public in response to this consultation document[3]. The PMRA will then publish a Registration Decision[4] on carfentrazone-ethyl, which will include the decision, the reasons for it, a summary of comments received on the proposed final registration decision and the PMRA's response to these comments.

For more details on the information presented in this Overview, please refer to the Science Evaluation of this consultation document.

What Is Carfentrazone-ethyl?

Carfentrazone-ethyl is a herbicide belonging to the aryl triazolinone chemical family. Carfentrazone-ethyl is rapidly absorbed by plant leaves and works by inhibiting the enzyme protoporphyrinogen oxidase in the chlorophyll biosynthetic pathway, which leads to cell membrane disruption and desiccation resulting in rapid development of chlorotic to necrotic symptoms and ultimately plant death.

Carfentrazone-ethyl is classified as a Group 14 herbicide by the Weed Science Society of America and as a Group E herbicide by the Herbicide Resistance Action Committee.

Quicksilver Herbicide contains the active ingredient carfentrazone-ethyl at 224 grams per litre of product. Quicksilver Herbicide is a post-emergence herbicide, i.e., a herbicide applied after the moss has emerged from the ground, which is applied using ground equipment to golf greens and tees consisting of creeping bentgrass, colonial bentgrass and annual bluegrass for the control of silvery-thread moss (*Bryum argenteum*).

Health Considerations

Can Approved Uses of Carfentrazone-ethyl Affect Human Health?

Exposure to carfentrazone-ethyl may occur through diet (food and water) or when handling and applying the product. When assessing health risks, two key factors are considered: the levels at which no health effects occur and the levels to which people may be exposed. The dose levels used to assess risks are established to protect the most sensitive human population (for example, children and nursing mothers). Only uses for which the exposure is well below levels that cause no effects in animal testing are considered acceptable for registration.

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3 "Consultation statement" as required by subsection 28(2) of the *Pest Control Products Act*.

4 "Decision statement" as required by subsection 28(5) of the *Pest Control Products Act*.

Toxicology studies in laboratory animals describe the potential health effects from varying levels of exposure to a chemical and identify the dose where no effects are observed. The health effects noted in animals occur at doses more than 100-times higher (and often much higher) than levels to which humans are normally exposed when using the carfentrazone-ethyl product according to label directions.

The end-use product, Quicksilver Herbicide, is considered to be chemically and toxicologically equivalent to the currently registered end-use product, Aim EC Herbicide (Reg. No. 28573), with low acute oral, dermal and inhalation toxicity. It is slightly irritating to the eyes and skin and does not cause an allergic skin reaction.

When tested in laboratory animals, carfentrazone-ethyl was not oncogenic, genotoxic or neurotoxic. Animal studies also demonstrated that carfentrazone-ethyl had no effects on reproductive toxicity, developmental toxicity, or teratogenicity. There was no evidence that carfentrazone-ethyl affected the immune and endocrine systems. The toxicity data did not demonstrate an increased sensitivity of the young to the toxic potential of carfentrazone-ethyl when compared to the adult animals

Risks in Residential and Other Non-Occupational Environments

There are no proposed residential uses of Quicksilver Herbicide. Bystanders may come in contact with residues on the skin while golfing on treated golf course tees and greens. This exposure is expected to be much less than that for workers and is considered negligible. Therefore, health risks to bystanders are not of concern.

Occupational Risks From Handling Quicksilver Herbicide

Occupational risks are not of concern when Quicksilver Herbicide is used according to the proposed label directions, which include protective measures.

Workers and custom applicators who mix, load or apply Quicksilver Herbicide as well as workers re-entering freshly treated golf courses can come in direct contact with carfentrazone-ethyl residues on the skin. Therefore, the label specifies that anyone mixing/loading Quicksilver Herbicide must wear a long-sleeved shirt, long pants, chemical resistant gloves and shoes plus socks, and that anyone applying the product must wear a long-sleeved shirt, long pants, and shoes plus socks. The label also requires that workers do not enter treated areas until the spray has dried. Taking into consideration these label statements and the expectation that occupational exposure is to be short-term for workers, the risks to mixers/loaders, applicators and re-entry workers are not a concern.

Environmental Considerations

What Happens When Carfentrazone-ethyl Is Introduced Into the Environment?

When carfentrazone-ethyl is applied for control of weeds in turf, some of it finds its way into soil and water. However, carfentrazone-ethyl is rapidly broken down by soil microbes and by chemical reaction in water, thus, is not expected to persist in the environment. Its major transformation products will be present in soil and aquatic systems for a longer period of time. Laboratory studies indicate that carfentrazone-ethyl and its transformation products are mobile in soil. There is, however, no field evidence that the use of this herbicide will result in groundwater contamination, indicating that leaching in soil is offset by biotransformation processes; therefore, potential for groundwater contamination would be low.

When carfentrazone-ethyl is used for weed control in turf, there is a potential that nontarget plant species on land and in water may be exposed to the chemical as a result of spray drift or runoff. Some plant species are sensitive to the chemical and would be adversely affected. In order to minimize the potential exposure, strips of land (buffer zones) between the treated area and the nontarget terrestrial or aquatic areas will be left unsprayed. The width of these buffer zones will be specified on the product label. Water monitoring data were not available at the time of this review. Carfentrazone-ethyl presents negligible risk to wild birds and mammals, bees and other arthropods.

Value Considerations

What Is the Value of Quicksilver Herbicide?

Quicksilver Herbicide, a post-emergence herbicide, controls silvery-thread moss (*Bryum argenteum*) in golf course greens and tees consisting of established creeping bentgrass, colonial bentgrass and annual bluegrass or consisting of newly seeded, sodded or sprigged creeping bentgrass.

One or more post-emergence applications (maximum of 440 g carfentrazone-ethyl/ha per year) of Quicksilver Herbicide along with a non-ionic surfactant (at 0.25% volume/volume) provides effective control of silvery-thread moss in golf course greens consisting of established creeping bentgrass, colonial bentgrass and annual bluegrass or consisting of newly seeded, sodded or sprigged creeping bentgrass.

Measures to Minimize Risk

Labels of registered pesticide products include specific instructions for use. Directions include risk-reduction measures to protect human and environmental health. These directions must be followed by law.

The key risk-reduction measures being proposed on the label of Quicksilver Herbicide to address the potential risks identified in this assessment are as follows.

Key Risk-Reduction Measures

Human Health

Workers and custom applicators who mix, load or apply Quicksilver Herbicide as well as workers re-entering freshly treated golf courses can come in direct contact with carfentrazone-ethyl residues on the skin. Therefore, the label specifies that anyone mixing/loading Quicksilver Herbicide must wear a long-sleeved shirt, long pants, chemical resistant gloves and shoes plus socks, and that anyone applying the product must wear a long-sleeved shirt, long pants, and shoes plus socks. The label also requires that workers do not enter treated areas until the spray has dried. Taking into consideration these label statements and the expectation that occupational exposure is to be short-term for workers, the risks to mixers/loaders, applicators and re-entry workers are not a concern.

Environment

To protect sensitive terrestrial and aquatic plant species from the turf use of carfentrazone-ethyl mitigative measures are recommended. These include adding precautionary statements to the label regarding environmental hazards and the directions for use, as well as a 10 m buffer zone to protect sensitive terrestrial plants from spray drift.

Next Steps

Before making a final registration decision on carfentrazone-ethyl, the PMRA will consider all comments received from the public in response to this consultation document. The PMRA will accept written comments on this proposal up to 45 days from the date of publication of this document. Please forward all comments to Publications (contact information on the cover page of this document). The PMRA will then publish a Registration Decision, which will include its decision, the reasons for it, a summary of comments received on the proposed final decision and the Agency's response to these comments.

Other Information

When the PMRA makes its registration decision, it will publish a Registration Decision on carfentrazone-ethyl (based on the Science Evaluation of this consultation document). In addition, the test data referenced in this consultation document will be available for public inspection, upon application, in the PMRA's Reading Room (located in Ottawa).

Science Evaluation

Carfentrazone-ethyl

1.0 The Active Ingredient, Its Properties and Uses

1.1 Physical and Chemical Properties of the Active Ingredients and End-Use Product

Technical Product - Aim (Carfentarzone-ethyl) Technical Herbicide

Please refer to PRDD2009-06. *Carfentrazone-ethyl* for detailed chemistry assessment for Aim (Carfentrazone-ethyl) Technical Herbicide.

End-Use Product – Quicksilver Herbicide

Property	Result
Colour	Not applicable
Odour	Not applicable
Physical state	Viscous liquid
Formulation type	EC (emulsifiable concentrate)
Guarantee	Carfentrazone-ethyl at 224 g/L
Container material and description	Fluorinated high density polyethylene bottle (HDPE), 237-945 mL
Density	1.0548 g/mL
pH of 1% dispersion in water	4.29
Oxidizing or reducing action	Does not contain strong oxidizing or reducing agents
Storage stability	Stable for one year at ambient temperature
Corrosion characteristics	No signs of corrosion after storage for one year at ambient temperature
Explodability	The product is not expected to be explosive

1.2 Directions for Use

1.2.1 Quicksilver Herbicide

Quicksilver Herbicide, containing carfentrazone-ethyl, is a selective herbicide for use as a post-emergent treatment in golf course greens and tees consisting of established creeping bentgrass, colonial bentgrass and annual bluegrass or consisting of newly seeded, sodded or sprigged creeping bentgrass for the control of silvery-thread moss (*Bryum argenteum*). This is a commercial class product that may be applied one or more times per growing season for post-emergence control of silvery-thread moss at a rate of 33 to 110 g a.i./ha and must be applied with a non-ionic surfactant such as Agral 90 or Ag-Surf at a rate of 0.25% v/v (e.g., 25 mL of surfactant per 100 L of water), see table below. QuickSilver Herbicide is applied as a broadcast treatment with ground application equipment only up to a maximum cumulative rate of 440 g a.i./ha per year.

Rates of Application for Quicksilver Herbicide

Timing	Herbicide Rate	Weed Controlled
Burndown and control	One or more applications at a rate of 110 g a.i./ha + 0.25% v/v of non-ionic surfactant, such as Agral 90 or Ag-Surf with repeated applications at a 2-week interval, up to a maximum annual rate of 440 g a.i./ha.	Silvery-thread moss
Control over longer periods	Multiple applications at a rate of 33 to 110 g a.i./ha + 0.25% v/v of non-ionic surfactant, such as Agral 90 or Ag-Surf repeated every 2 weeks, up to a maximum annual rate of 440 g a.i./ha.	Silvery-thread moss

1.3 Mode of Action

Carfentrazone-ethyl is classified as a Group 14 Herbicide (refer to Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action). The primary mode of action of carfentrazone-ethyl is the inhibition of the enzyme protoporphyrinogen oxidase in the chlorophyll biosynthetic pathway and leads to the subsequent buildup of phytotoxic intermediates and disruption of cell membranes. Plants treated with carfentrazone-ethyl become necrotic and die shortly after treatment. Initial symptoms are observed within hours and death occurs within a few days.

2.0 Methods of Analysis

2.1 Method for Formulation Analysis

The method provided for the analysis of the active ingredient in the formulation has been validated and assessed to be acceptable for use as an enforcement analytical method.

3.0 Impact on Human and Animal Health

3.1 Toxicology Summary

Please refer to PRDD2009-06. *Carfentrazone-ethyl* for a detailed assessment of the toxicology of carfentrazone-ethyl.

3.1.1 PCPA Hazard Characterization

For assessing risks from potential residues in food or from products used in or around homes or schools, the Pest Control Products Act requires the application of an additional 10-fold factor to threshold effects to take into account completeness of the data with respect to the exposure of, and toxicity to, infants and children, and potential prenatal and postnatal toxicity. A different factor may be determined to be appropriate on the basis of reliable scientific data.

With respect to the completeness of the toxicity database as it pertains to the toxicity to infants and children, extensive data were available for carfentrazone. The database contains the full complement of required studies including developmental toxicity studies in rats and rabbits and a reproductive toxicity study in rats.

With respect to potential prenatal and postnatal toxicity, no evidence of sensitivity of the young was observed in the 2-generation reproductive toxicity study. Parents demonstrated clinical effects, changes in haematological paramters, liver effects and marginal body weight loss at the highest dose tested. Offspring exhibited decreased body weight at the highest dose tested. In the developmental toxicity studies in rats and rabbits, no adverse toxicological effects were observed. Consequently the 10-fold factor required under the Pest Control Products Act was reduced to 1-fold.

3.2 Determination of Acute Reference Dose

Please refer to PRDD2009-06. *Carfentrazone-ethyl* for the determination of the acute reference dose of carfentrazone-ethyl.

3.3 Determination of Acceptable Daily Intake

Please refer to PRDD2009-06. *Carfentrazone-ethyl* for the determination of the acceptable daily intake of carfentrazone-ethyl.

3.4 Occupational and Residential Risk Assessment

3.4.1 Toxicological Endpoints

Please refer to PRDD2009-06. *Carfentrazone-ethyl* for the selection of toxicological endpoints for carfentrazone-ethyl.

3.4.1.1 Dermal Absorption

Please refer to PRDD2009-06. *Carfentrazone-ethyl* for the determination of dermal absorption for carfentrazone-ethyl.

3.4.2 Occupational Exposure and Risk

3.4.2.1 Mixer/loader/applicator Exposure and Risk Assessment

Individuals have potential for exposure to carfentrazone-ethyl during mixing, loading and application to golf course greens and tees. Exposure to workers mixing, loading and applying Quicksilver Herbicide is expected to be short-term in duration and to occur primarily by the dermal and inhalation routes. Given that a short-term risk assessment is not required due to the absence of toxicological triggers, exposure estimates were not derived for short-term exposure.

3.4.2.2 Exposure and Risk Assessment for Workers Entering Treated Areas

There is potential for exposure to workers re-entering areas treated with Quicksilver Herbicide when mowing, scouting, or other maintenance activities in golf courses, which would occur mainly through the dermal route. Given the reoccurring nature of activities performed and the 6-months of potential pest pressure, the duration of exposure is considered to be intermediate-term in length.

Dermal exposure to workers entering treated areas is estimated by coupling turf transferable residue values with activity-specific transfer coefficients. Activity transfer coefficients are based on Agricultural Re-entry Task Force (ARTF) data. Chemical-specific dislodgeable foliar residue data were not submitted. As such, a default turf transferable residue value of 5% of the application rate was used in the exposure assessment. Exposure was assessed after four applications made 14 days apart at the maximum rate (110 g a.i./ha). Exposure estimates were compared to the toxicological endpoint to obtain the margin of exposure (MOE); the target MOE is 100. The MOEs were well above the target MOE of 100 (see Table below) and therefore there were no risks of concern.

Postapplication Margin of Exposure to Workers Re-entering Treated Golf Courses

Activity	App Rate[1] (µg/cm²)	Day 0 TTR[2] (µg/cm²)	TCs[3] (cm²/hr)	Exposure[4] (mg/kg bw/day)	MOE[5]
Mowing, watering, cup changing, irrigation repair, grooming	1.1	0.0711	3500	0.0284	5,273
Aerating, fertilizing, hand pruning, mechanical weeding, scouting, seeding	1.1	0.0711	500	0.0041	36,910

1 Application rate (µg/cm²) = maximum rate (1.1) assuming 4 applications made 14 days apart

2 TTR = turf transferable residue on the day after the last application (default = 5% of the application rate, with a default 10% dissipation/day)

3 From *Interim Transfer Coefficients for Golf Course and Sod Farm Post-Application Activities*, December 22, 2008

4 Exposure = [Day 0 DFR after Last App (µg/cm²) x TC (cm²/hr) x DA (100%) x Workday (8 hr)]/(70 kg bw x 1000 µg/mg)

5 MOE = NOAEL (mg/kg bw/day)/Exposure (mg/kg bw/day); NOAEL = 150 mg/kg bw/day, target MOE = 100

3.4.3 Non-Occupational and Residential Exposure and Risk Assessment

3.4.3.1 Handler Exposure and Risk

Please refer to PRDD2009-06. *Carfentrazone-ethyl* for a detailed assessment of the handler exposure and risk for carfentrazone-ethyl.

3.4.3.2 Postapplication Exposure and Risk

Golfers may come in contact with residues on the skin while golfing on treated golf courses and greens, and re-entry exposure would occur mainly via the dermal route. This exposure is expected to be intermittent and short-term in duration. Since no short-term dermal toxicological concerns were identified for carfentrazone-ethyl, postapplication exposure is not of concern for golfers coming in contact with treated golf course turf. An aggregate exposure and risk assessment is not required, as no acute reference dose was identified for carfentrazone-ethyl.

3.4.3.3 Bystander Exposure and Risk

Bystander exposure should be negligible since the potential for drift is expected to be minimal. Application is limited to when there is low risk of drift to areas of human habitation or activity such as houses, cottages, schools and recreational areas, taking into consideration wind speed, wind direction, temperature inversions, application equipment and sprayer settings.

4.0 Impact on the Environment

4.1 Fate and Behaviour in the Environment

Based on its physical-chemical properties, carfentrazone-ethyl is very soluble in water, is not likely to volatilize from moist soil or water surfaces under field conditions, and is not likely to bioaccumulate in organisms. Environmental fate data for carfentrazone-ethyl are summarized in Table 1 of Appendix I. Carfentrazone-ethyl is relatively labile and dissipates from soil and aquatic systems by hydrolysis and biotransformation. At cooler temperatures, the dissipation of carfentrazone-ethyl is slower in all environmental media. Phototransformation is an important route of transformation for carfentrazone-ethyl in water and air, but not in soil. Carfentrazone-ethyl is not persistent in soil, but its major transformation products are generally more persistent than the parent compound. Water/sediment studies demonstrated that the majority of the applied radioactivity is preferentially associated with the water. All transformation products were polar and were largely associated with the aqueous phase. There was no evidence of significant accumulation of either parent compound or its transformation products in the sediment.

Laboratory studies on adsorption/desorption and soil column leaching indicate that carfentrazone-ethyl is not mobile. However, its transformation products have a potential to be mobile in a variety of soils. Carfentrazone-ethyl has no potential for leaching, but some of its transformation products do. However, not only carfentrazone-ethyl, but also its transformation products were detected in only the top 10 20 cm deep soil layer in a terrestrial filed study. Most probably, leaching was offset by transformation processes; therefore, potential for groundwater contamination would be low. Water monitoring data were not available.

4.2 Environmental Risk Characterization

The environmental risk assessment integrates the environmental exposure and ecotoxicology information to estimate the potential for adverse effects on non-target species. This integration is achieved by comparing exposure concentrations with concentrations at which adverse effects occur. Estimated environmental exposure concentrations (EECs) are concentrations of pesticide in various environmental media, such as food, water, soil and air. The EECs are estimated using standard models which take into consideration the application rate(s), chemical properties and environmental fate properties, including the dissipation of the pesticide between applications. Ecotoxicology information includes acute and chronic toxicity data for various organisms or groups of organisms from both terrestrial and aquatic habitats including invertebrates, vertebrates, and plants. Toxicity endpoints used in risk assessments may be adjusted to account for potential differences in species sensitivity as well as varying protection goals (i.e. protection at the community, population, or individual level).

Initially, a screening level risk assessment is performed to identify pesticides and/or specific uses that do not pose a risk to non-target organisms, and to identify those groups of organisms for which there may be a potential risk. The screening level risk assessment uses simple methods, conservative exposure scenarios (e.g. direct application at a maximum cumulative application rate) and sensitive toxicity endpoints. A risk quotient (RQ) is calculated by dividing the exposure estimate by an appropriate toxicity value (RQ = exposure/toxicity), and the risk quotient is then

compared to the level of concern (LOC = 1). If the screening level risk quotient is below the level of concern, the risk is considered negligible and no further risk characterization is necessary. If the screening level risk quotient is equal to or greater than the level of concern, then a refined risk assessment is performed to further characterize the risk. A refined assessment takes into consideration more realistic exposure scenarios (such as drift to non-target habitats) and might consider different toxicity endpoints. Refinements may include further characterization of risk based on exposure modelling, monitoring data, results from field or mesocosm studies, and probabilistic risk assessment methods. Refinements to the risk assessment may continue until the risk is adequately characterized or no further refinements are possible.

4.2.1 Risks to Terrestrial Organisms

A risk assessment of carfentrazone-ethyl to terrestrial organisms was based upon an evaluation of toxicity data on carfentrazone-ethyl to earthworms (acute contact), bees (acute oral and chronic), predatory and/or parasitic invertebrates, birds (acute oral, dietary, and chronic), mammals (acute oral, dietary, and chronic), and ten species of terrestrial plants (seed germination, seedlings emergence and vegetative vigour). A summary of terrestrial toxicity data for carfentrazone-ethyl is presented in Table 2 (Appendix I). For the assessment of risk, toxicity endpoints chosen from the most sensitive species were used as surrogates for the wide range of species that can be potentially exposed following treatment with carfentrazone-ethyl.

Carfentrazone-ethyl exerted no adverse toxicological effects on terrestrial invertebrates, birds or mammals on an acute, dietary and reproductive basis. As carfentrazone-ethyl is a herbicide, adverse effects to non target terrestrial plants are expected. Plant emergence and vegetative vigour studies conducted with ten plant species indicated that, although the seeds of most plant species emerged successfully, plants did not follow normal growth patterns due to the ability of carfentrazone-ethyl to inhibit the plant enzyme, protoporphyrinogen oxidase (PPO). This action results in membrane disruption, which ultimately kills sensitive weeds by interfering with the chlorophyll biosynthetic pathway. Symptoms of carfentrazone-ethyl toxicity were mainly manifested as retarded growth with some necrosis. No toxicity studies conducted with carfentrazone-ethyl transformation products were available for review.

The screening level risk assessment conducted for cumulative application rate (turf use only) of 381 g ai/ha (four applications of 112 g ai/ha with 14 d intervals; t ½ 86 d), indicated that exposure to carfentrazone-ethyl does not pose a risk to terrestrial invertebrates, mammals and birds. Tables 3 and 4 (Appendix I) summarize the risk assessment for terrestrial organisms exposed to carfentrazone-ethyl.

As would be expected, the herbicide carfentrazone-ethyl poses a risk to non target terrestrial plants. The LOC was exeeded by as much as 381 times. As a result, a refinement of the risk assessment was conducted taking into consideration the concentrations of carfentrazone-ethyl that could be present in terrestrial habitat directly adjacent to the application field through drift of spray. Spray drift data for a medium ASAE droplet size, as is generally used in ground boom applications of herbicides, indicate that the maximum amount of spray that will drift one metre down wind from the point of application during spraying is 6% of that applied. Using this percent drift, the off site EECs for carfentrazone-ethyl were calculated. Based on this method of

refinement, carfentrazone-ethyl poses a reduced risk to non-target terrestrial plants directly adjacent to the application field. Exceedance of the LOC was reduced from 177 to 11 times. Buffer zones will be required to mitigate the risk of carfentrazone-ethyl to non target terrestrial plants. Table 5 (Appendix I) summarizes the refined risk assessment for non target terrestrial plants exposed to carfentrazone-ethyl.

4.2.2 Risks to Aquatic Organisms

Risk to aquatic organisms, acute and chronic, is based on an evaluation of toxicity data on carfentrazone-ethyl for eight freshwater species (one invertebrate, two fish, two algae, one diatom, and one vascular plant) and four estuarine/marine species (two invertebrates, fish and alga). Some toxicity data on the transformation products were also available. A summary of aquatic toxicity data for carfentrazone-ethyl and its transformation products is presented in Table 2 (Appendix I). For the assessment of risk, toxicity endpoints chosen from the most sensitive species were used as surrogates for the wide range of species that can be potentially exposed following treatment with carfentrazone-ethyl.

Carfentrazone-ethyl and its transformation products are not toxic to freshwater and marine invertebrates and fish on acute bases. However, chronic effects to freshwater fish and amphibians were identified. No chronic toxicity data were available for estuarine/marine species. As carfentrazone-ethyl is a herbicide, adverse effects to non target aquatic plants are expected. Carfentrazone-ethyl affected biomass and cell density of freshwater and marine/estuarine algae. Carfentrazone-ethyl affected frond density and biomass of duckweed. The transformation products did not adversely affect algae or duckweed at the maximum concentrations tested.

The risk assessment was conducted using data for the most sensitive freshwater organisms tested Daphnia magna, rainbow trout (*Oncorhynchus mykiss*), diatom (*Navicula pelliculosa*) and duckweed (*Lemna gibba*) as well as marine/estuarine algae (*Skeletonema costatum*).

The screening level risk assessment conducted for cumulative application rate of 395 g ai/ha (four applications of 112 g ai/ha with 14 d intervals; t ½ 112 d), indicated that carfentrazone-ethyl does not pose an acute risk to aquatic invertebrates and fish. However, a potential chronic risk to amphibians (based on surrogate data from fish studies) and fish, as well as acute risk for amphibians, algae and vascular plants was identified. Thus, a refined risk assessment was triggered which reduced the exceedance of the LOC from 16 to 2. There is also potential risk from runoff to freshwater algae and vascular plants (LOC exeeded by 1 and 1.1 times, respectively). Label statements will be required to mitigate the risk of carfentrazone-ethyl to non-target aquatic plants from spray drift and run-off. Table 6 (Appendix I) summarizes the risk assessment for aquatic organisms exposed to carfentrazone-ethyl. Tables 7 and 8 (Appendix I) summarize the refined risk assessment for aquatic organisms exposed to carfentrazone-ethyl spray drift and runoff, respectively. As monitoring data were not available, they were not considered in the risk assessment.

5.0 Value

5.1 Effectiveness Against Pests

5.1.1 Acceptable Efficacy Claims for Quicksilver Herbicide

Efficacy data were submitted from 5 replicated field trials conducted from 2003 to 2006 at several locations in Michigan and North Carolina, USA. Various rates and numbers of applications of carfentrazone-ethyl were assessed to determine the lowest effective rate. The herbicide treatments were applied using small plot application equipment.

The efficacy of Quicksilver Herbicide was visually assessed as percent weed control or percent turf recovery and compared to an untreated check. Observations were made at various times throughout the growing season. The data support the weed control claim summarized in the table below when Quicksilver Herbicide is applied as a post-emergence treatment with a non-ionic surfactant, such as Agral 90 or Ag-Surf.

Weed Control Claims Quicksilver Herbicide

Timing	Herbicide Rate	Weed Controlled
Burndown and control	One or more applications at a rate of 110 g a.i./ha + 0.25% v/v of non-ionic surfactant, such as Agral 90 or Ag-Surf with repeated applications at a 2-week interval, up to a maximum annual rate of 440 g a.i./ha.	Silvery-thread moss
Control over longer periods	Multiple applications at a rate of 33 to 110 g a.i./ha + 0.25% v/v of non-ionic surfactant, such as Agral 90 or Ag-Surf repeated every 2 weeks, up to a maximum annual rate of 440 g a.i./ha.	Silvery-thread moss

5.2 Phytotoxicity to Host Plants

5.2.1 Acceptable Claims for Host Plants for Quicksilver Herbicide

Data from 7 replicated field trials conducted from 2003 to 2006 at several locations in Michigan and North Carolina, USA were submitted in support of the host crop tolerance claims of newly seeded creeping bentgrass or established bentgrass and annual bluegrass. Some trials included treatments of QuickSilver Herbicide applied at the 2X maximum proposed rate.

Crop injury was visually assessed up to sixteen times during the growing season. Crop injury data for treatments of QuickSilver applied with a non-ionic surfactant support a crop tolerance claim for established creeping bentgrass, colonial bentgrass and annual bluegrass and for newly seeded, sodded or sprigged creeping bentgrass (see table below).

Host Crop Claims for Quicksilver Herbicide

Timing	Herbicide Rate	Crops
Burndown and control	One or more applications at a rate of 110 g a.i./ha + 0.25% v/v of non-ionic surfactant, such as Agral 90 or Ag-Surf with repeated applications at a 2-week interval, up to a maximum annual rate of 440 g a.i./ha.	- Established creeping bentgrass, colonial bentgrass and annual bluegrass - Newly seeded, sodded or sprigged creeping bentgrass
Control over longer periods	Multiple applications at a rate of 33 to 110 g a.i./ha + 0.25% v/v of non-ionic surfactant, such as Agral 90 or Ag-Surf repeated every 2 weeks, up to a maximum annual rate of 440 g a.i./ha.	- Established creeping bentgrass, colonial bentgrass and annual bluegrass - Newly seeded, sodded or sprigged creeping bentgrass

5.3 Impact on Succeeding Crops

Not applicable.

5.4 Economics

Silvery-thread moss (*Bryum argenteum*) has become an important management consideration on creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) greens and tees. Once thought to be only of concern in moist areas receiving low light intensity and mild climates, this non-vascular plant is invading turf areas. Today, silvery-thread moss is found in many areas previously considered unsuitable for this type of plant growth. Control of silvery-thread moss growth is a potential management consideration wherever creeping bentgrass and annual bluegrass are grown under intensive management practices, such as those employed on most putting greens.

Gradual changes in management practices on greens have contributed to increased moss infestation. These changes are: (1) lower mowing height and mowing cycles to achieve faster speed of roll; and, (2) changes in fertility programs reducing the nitrogen input resulting in reduced turf density and opportunity for moss to become established. Other factors that may encourage increased moss establishment include irrigation, shade and poor air circulation. Many of these factors can be managed; however, the desire for faster greens may override the ability to provide cultural management of a moss problem. Therefore, chemical control measures can be part of a moss control program.

5.5 Sustainability

5.5.1 Survey of Alternatives

There is no herbicide registered in Canada for the control of silvery-thread moss in creeping bentgrass. Non-chemical controls include complete renovation of the greens and tees. Management techniques that encourage dense turfgrass that can compete with silvery-thread moss encroachment include raising the mowing height, rolling the turf, use of growth regulators and fertilizers, and minimizing topdressing with sand. However, these practices are in conflict with achieving green speeds required by today's golfing standards.

5.5.2 Compatibility with Current Management Practices Including Integrated Pest Management

Quicksilver Herbicide is a post-emergent herbicide that can target existing infestation of silvery-thread moss and, as such, offers an additional tool for golf greens and tees management practices.

5.5.3 Information on the Occurrence or Possible Occurrence of the Development of Resistance

Quicksilver Herbicide is a Group 14 herbicide. No other herbicides are registered for moss control in golf greens and tees; therefore, rotation with herbicides with different modes of action and tank-mixing with other herbicides are not an option for resistance management. The use of this product is limited to small populations of silvery-thread moss occurring in golf greens and tees; therefore the likelihood of developing resistance is low. Once the moss is under control, cultural methods and integrated pest management can be used to reduce the re-establishment of silvery-thread moss on green and tee surfaces.

6.0 Pest Control Product Policy Considerations

The Toxic Substances Management Policy (TSMP) is a federal government policy developed to provide direction on the management of substances of concern that are released into the environment. The TSMP calls for the virtual elimination of Track 1 substances [those that meet all four criteria outlined in the policy, i.e., persistent (in air, soil, water and/or sediment), bio-accumulative, primarily a result of human activity and toxic as defined by the *Canadian Environmental Protection Act*].

During the review process, carfentrazone-ethyl and its transformation products were assessed in accordance with the PMRA Regulatory Directive DIR99-03[5] and evaluated against the Track 1 criteria. The PMRA has reached the following conclusions:

Carfentrazone-ethyl does not meet Track 1 criteria, and is not considered a Track 1 substance. See Table 10 (Appendix I) for comparison with Track 1 criteria

Carfentrazone-ethyl does not form any transformation products that meet all Track 1 criteria.

6.1 Formulants and Contaminants of Health or Environmental Concern

During the review process, contaminants in the technical and formulants and contaminants in the end-use products are compared against the *List of Pest control Product Formulants and Contaminants of Health or Environmental Concern* maintained in the *Canada Gazette*[6]. The list is used as described in the PMRA Notice of Intent NOI2005-01[7] and is based on existing policies and regulations including: DIR99-03; and DIR2006-02[8], and taking into consideration the Ozone-depleting Substance Regulations, 1998, of the *Canadian Environmental Protection Act* (substances designated under the Montreal Protocol). The PMRA has reached the following conclusions:

Technical grade carfentrazone-ethyl and the end-use product Quicksilver Herbicide do not contain any formulants or contaminants of health or environmental concern identified in the *Canada Gazette*. However, the end-use product does contain an aromatic petroleum distillate. Therefore, the label for the end-use product Quicksilver will include the following statement: **"This product contains aromatic petroleum distillates that are toxic to aquatic organisms."**

The use of formulants in registered pest control products is assessed on an ongoing basis through PMRA formulant initiatives and Regulatory Directive DIR2006-02[9].

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5 DIR99-03, *The Pest Management Regulatory Agency's Strategy for Implementing the Toxic Substances Management Policy*

6 *Canada Gazette*, Part II, Volume 139, Number 24, SI/2005-114 (2005-11-30) pages 2641–2643: *List of Pest Control Product Formulants and Contaminants of Health or Environmental Concern* and in the order amending this list in the *Canada Gazette*, Part II, Volume 142, Number 13, SI/2008-67 (2008-06-25) pages 1611-1613. *Part 1 Formulants of Health or Environmental Concern, Part 2 Formulants of Health or Environmental Concern that are Allergens Known to Cause Anaphylactic-Type Reactions and Part 3 Contaminants of Health or Environmental Concern.*

7 NOI2005-01, List of Pest Control Product Formulants and Contaminants of Health or Environmental Concern under the New Pest Control Products Act.

8 DIR2006-02, PMRA Formulants Policy.

9 DIR2006-02, PMRA Formulants Policy.

7.0 Summary

7.1 Human Health and Safety

The toxicology database submitted for carfentrazone-ethyl is adequate to define the toxic effects that may result from human exposure. In short- and long-term toxicity studies in laboratory animals, carfentrazone-ethyl caused systemic toxicity at high dose levels and organ toxicity associated with metabolism and detoxification of orally administered carfentrazone-ethyl. Observed systemic toxicity at high doses included effects on food consumption, body weight and body-weight gain. Organ toxicity invariably involved the liver and the kidneys. One other notable observation was the effect of carfentrazone-ethyl on porphyrin metabolism, which resulted in increased urinary excretion of various porphyrin components. There was no evidence of other toxic effects, including carcinogenicity, mutagenicity, teratogenicity, neurotoxicity, reproductive toxicity or increased susceptibility of the young.

Workers who mix, load or apply QuickSilver Herbicide and who re-enter treated areas are not expected to be exposed to levels of carfentrazone-ethyl that will result in an unacceptable risk when QuickSilver Herbicide is used according to label directions. The personal protective equipment on the product label is adequate to protect workers.

7.2 Environmental Risk

Carfentrazone-ethyl is non-persistent in most soils and water systems, although its transformation products are more persistent than the parent compound. There is a potential that carfentrazone-ethyl may appear in surface water through runoff. The risk assessment of carfentrazone-ethyl indicates that there is a potential for adverse effects on non-target terrestrial and aquatic plants. To reduce the effects of carfentrazone-ethyl in the environment, mitigation in the form of precautionary label statements and buffer zones are required. Carfentrazone-ethyl presents negligible risk to wild birds and mammals, bees and other arthropods. It does, however, pose a risk to aquatic organisms such as fish, amphibians and invertebrates.

7.3 Value

The data submitted to register Quicksilver Herbicide are adequate to describe its efficacy for use in established creeping bentgrass, colonial bentgrass and annual bluegrass or in newly seeded, sodded or sprigged creeping bentgrass for the post-emergence control of silvery-thread moss (*Bryum argenteum*). One or more applications of Quicksilver Herbicide at 110 g a.i./ha plus 0.25% v/v of a non-ionic surfactant such as Agral 90 or Ag-Surf with repeated applications at 2-week interval (up to a maximum annual rate of 440 g a.i./ha) provide burndown and control of silvery-thread moss. Applications of 33 to 110 g a.i./ha of QuickSilver Herbicide plus 0.25% v/v of a non-ionic surfactant such as Agral 90 or Ag-Surf, repeated every two weeks (up to a maximum annual rate of 440 g a.i./ha) provide control of silvery-thread moss over longer periods.

7.4 Unsupported Uses

Certain host turfgrass species originally proposed by the applicant were not supported by the PMRA because no efficacy claims were specified for these host crops and because none of these host crops are found or used in golf greens and tees. The unsupported host crops include the following grasses: Kentucky bluegrass, fine fescue, red fescue, tall fescue and perennial ryegrass.

8.0 Proposed Regulatory Decision

Health Canada's PMRA, under the authority of the *Pest Control Products Act* and Regulations, is proposing full registration for the sale and use of Aim (Carfentrazone-ethyl) Technical Herbicide and Quicksilver Herbicide, containing the technical grade active ingredient carfentrazone-ethyl, to control silvery-thread moss in golf course greens and tees.

An evaluation of available scientific information found that, under the approved conditions of use, the product has value and does not present an unacceptable risk to human health or the environment.

List of Abbreviations

µg	microgram
a.i.	active ingredient
ADI	acceptable daily intake
ARfD	acute reference dose
cm	centimetre (s)
cm2	centimetre (s) squared
d	day
DA	dermal absorption
EC25	effective concentration on 25% of the population
EC50	effective concentration on 50% of the population
EEC	estimated environmental concentration
g	gram
h	hour
ha	hectare(s)
kg	kilogram
L	litre
LC_{50}	lethal concentration 50%
LD_{50}	lethal dose 50%
LOAEL	lowest observed adverse effect level
Kow	*n*–octanol-water partition coefficient
mg	milligram
mL	millilitre
mm	millimetre
MAS	maximum average score
MIS	maximum irritation score
MOE	margin of exposure
N/A	not applicable
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
PMRA	Pest Management Regulatory Agency
$t_{1/2}$	half-life
TTR	turf transferable residue
TSMP	Toxic Substances Management Policy
v/v	volume per volume dilution

Appendix I Tables and Figures

Table 1 Fate and behaviour in the terrestrial and aquatic environments

Study type	Test material	Study Conditions	Value or Endpoint	Interpretation	Major transformation products	Reference
Abiotic transformation						
Hydrolysis	Carfentrazone-ethyl	30 d	20°C 25°C pH 5 stable pH 7 13.7 d 8.6 d pH 9 0.21 d 0.15 d	Major route of transformation under neutral & basic conditions	carfentrazone-chloropropionic acid (stable to further hydrolysis)	PMRA 1155114 PMRA 1310349
Phototransformation - soil	Carfentrazone-ethyl	Loamy sand (pH 5.4, sand 80%, silt 14%, clay 6%, OM 3.4%)	stable (70% of parent was present after 30 d of exposure at 25°C)	Not a major route of transformation	not reported	PMRA 1150781
Phototransformation - water	Carfentrazone-ethyl	25 °C, pH 5	DT_{50} = 8.3 d	Major route of transformation	carfentrazone-chloropropionic acid	PMRA 1150779 PMRA 1150780
	Carfentrazone-ethyl	25 °C, pH 5-9	DT_{50} = 5.4-6.0 d		not reported	PMRA 1150782
Phototransformation - air	Carfentrazone-ethyl	Photochemical oxidative degradation	4.6 h	Major route of transformation	not reported	PMRA 1310349
Biotransformation						
Soil - aerobic	Carfentrazone-ethyl	20 °C; four soils: pH 4.5-5.8; % OC 2-3.4	DT_{50} = 0.1-1.3 d	Non-persistent	carfentrazone -chloropropionic acid -propionic acid -cinamic acid -benzoic acid	PMRA 1155116
	Carfentrazone-chloropropionic acid		DT_{50} = 11.3-85.6 d	Non-persistent to moderately persistent	not reported	PMRA 1155117
Soil - anaerobic	Carfentrazone-ethyl	20 °C; loamy sand (Speyer 2.2); pH 5.8 %OC 3.1	DT_{50} = 0.8 d	Non-persistent	carfentrazone -chloropropionic acid -propionic acid	PMRA 1155281

Study type	Test material	Study Conditions	Value or Endpoint	Interpretation	Major transformation products	Reference
Water/sediment - aerobic	Carfentrazone-ethyl	20 °C; two systems, pH 7.85-8.0 (water)	DT_{50}<1.2 d	Non-persistent. No significant accumulation in the sediment.	carfentrazone -chloropropionic acid -propionic acid -cinamic acid -benzoic acid	PMRA 1150765 PMRA 1310348 PMRA 1310349
	carfentrazone-chloropropionic acid		DT_{50} = 44-89 d (water) DT_{50} = 46-112 d (system)			PMRA 1310349
Mobility						
Adsorption/ desorption	Carfentrazone-ethyl	Five soils (pH 4.8-6.4, 0.2-3.4% OC)	not determined due to instability under the test conditions			PMRA 1310349
	carfentrazone-chloropropionic acid		K_{OC} = 7.4-46.4	Very high mobility		PMRA 1150764
	carfentrazone-propionic acid		K_{OC} = 51-260	High to moderate mobility		PMRA 1150762
	carfentrazone-cinamic acid		K_{OC} = 44-333	Very high to moderate mobility		
	carfentrazone-benzoic acid		K_{OC} = 4-41	Very high mobility		
Soil column leaching	Carfentrazone-ethyl	Five soils (pH 4.8-6.4, 0.2-3.4% OC) aged for 10 d	not detected in leachate	Not mobile		PMRA 1150778 PMRA 1155282
	carfentrazone-chloropropionic acid		0-66.2% in leachate	Mobile in soils tested		
	carfentrazone-cinamic acid		0.2-14.9 % in leachate			
	carfentrazone-benzoic acid		5.1-22.2 % in leachate			
Field studies						
Field dissipation	Carfentrazone-ethyl	One site relevant to Canadian conditions (Polk County, MN)	DT_{50} 5 d. No radioactivity found below 20 cm depth. The registrant-calculated half-life for the dissipation of the total residues was 32 d based on the first part of the biphasic degradation (0-61 DAT) and 108 d based on a linear degradation.		carfentrazone-chloropropionic acid -propionic acid -cinamic acid -benzoic acid	PMRA 1155283 PMRA 1150783

Table 2 Toxicity to non-target species

Organism	Study type	Species	Test material	Endpoint	Value (effect)	Effect	Reference
Terrestrial species							
Invertebrates	Acute oral	Honey bee (*Apis mellifera*)	Carfentrazone-ethyl 50 WG	24-h LD50	200 µg ai/bee	mortality	PMRA 1151787
	Acute contact	Earthworm (*Eisenia foetida*)	Carfentrazone-ethyl	14-d LC50	>820 mg ai/kg soil	mortality	PMRA 1310349
			carfentrazone-chloropropionic acid		>1000 mg ai/kg soil		PMRA 1153989
			carfentrazone-propionic acid				PMRA 1153995
			carfentrazone-cinamic acid				PMRA 1154004
			carfentrazone-benzoic acid				PMRA 1153985
		Honey bee (*Apis mellifera*)	Carfentrazone-ethyl	24-h LD50 48-h LD50	200 µg ai/bee >27.9 µg ai/bee	mortality	PMRA 1151787 PMRA 1151769
		Predatory mite (*Typhlodromus pyri*)	Carfentrazone-ethyl 50 WG 20-25 g ai/ha	14-d beneficial capacity	0% 0%	mortality fecundity	PMRA 1310349
		Parasitic wasp (*Aphidius rhopalosiphi*)			0% 3%	mortality fecundity	
		Carabid beetle (*Poecilus cupreus*)			0% 0%	mortality consumption	
		Staphylinid beetle (*Aleochara bilineata*)			0% 17%	mortality parasitism	
Birds	Acute oral	Bobwhite quail (*Colinus virginianus*)	Carfentrazone-ethyl	LD50	>2250 mg ai/kg bw	mortality	PMRA 1953193
	Dietary	Bobwhite quail (*Colinus virginianus*)		LC50	>5620 mg ai/kg diet	mortality	PMRA 1153981
	Dietary	Mallard duck (*Anas platyrhynchos*)		LC50	>5620 mg ai/kg diet	mortality	PMRA 1153982
	Chronic	Bobwhite quail (*Colinus virginianus*)		NOEC	1000 mg ai/kg diet	reproduction	PMRA 1154885
		Mallard duck (*Anas platyrhynchos*)		NOEC	1000 mg ai/kg di	reproduction	PMRA 1154884

Organism	Study type	Species	Test material	Endpoint	Value (effect)	Effect	Reference
Mammals	Acute oral	Rat	Carfentrazone-ethyl	LD50	5000 mg ai/kg bw	mortality	PMRA 1154880
	Dietary	Rat	Carfentrazone-ethyl	90 d NOEC	4000 mg ai/kg diet	growth	PMRA 1265815
	Chronic (2-generation)	Rat	Carfentrazone-ethyl	NOEC	1500 mg ai/kg diet	reproduction	PMRA 1265829
Plants	Seed germination	10 plant species	Carfentrazone-ethyl (rate 70 g ai/ha)	EC25	≥42.5 g ai/ha	radicle length	PMRA 1153203 PMRA 1153204
	Seedling emergence			EC25	≥19 g ai/ha	length=weight	
	Vegetative vigour			EC25	≥1.0 g ai/ha	weight	
Freshwater Organisms							
Invertebrates	Acute	*Daphnia magna*	Carfentrazone-ethyl	48-h EC50	> 9.8 mg ai/L	immobility	PMRA 1265727 PMRA 1310349
			carfentrazone-chloropropionic acid		> 101 mg ai/L		PMRA 1265748
			carfentrazone-propionic acid		> 102 mg ai/L		PMRA 1265744
			carfentrazone-cinamic acid		> 10.7 mg ai/L		PMRA 1265750
			carfentrazone-benzoic acid		> 92.8 mg ai/L		PMRA 1265741
	Chronic		Carfentrazone-ethyl	21-d NOEC	0.22 mg ai/L		PMRA 1310349

Organism	Study type	Species	Test material	Endpoint	Value (effect)	Effect	Reference
Fish	Acute	Rainbow trout (*Oncorhynchus mykiss*)	Carfentrazone-ethyl	96-h LC50	1.6 mg ai/L	mortality	PMRA 1265725
			carfentrazone-chloropropionic acid		> 99.2 mg ai/L		PMRA 1265747
			carfentrazone-propionic acid		> 95.6 mg ai/L		PMRA 1265745
			carfentrazone-cinamic acid		> 25.4 mg ai/L		PMRA 1265751
			carfentrazone-benzoic acid		> 92.5 mg ai/L		PMRA 1265742
		Bluegill sunfish (*Lepomis macrochirus*)	Carfentrazone-ethyl1		2.0 mg ai/L		PMRA 1265726
	Chronic (Early Life Stage)	Rainbow trout (*Oncorhynchus mykiss*)	Carfentrazone-ethyl	NOEC	0.118 mg ai/L 0.016 mg ai/L		PMRA 1154888 PMRA 1155112*
Algae	Acute	Green alga (*Selenastrum capricornutum*)	Carfentrazone-ethyl	EC50	16.2 µg ai/L 13.3 µg ai/L	growth and reproduction	PMRA 1265731 PMRA 1153991
			carfentrazone-chloropropionic acid		534 µg ai/L		PMRA 1265746
			carfentrazone-propionic acid		139 µg ai/L		PMRA 1265743
			carfentrazone-cinamic acid		112 µg ai/L 26.2 µg ai/L		PMRA 1154893 PMRA 1265749
			carfentrazone-benzoic acid		12.6 µg ai/L		PMRA 1265740
		Blue-green alga (*Anabaena flos-aquae*)	Carfentrazone-ethyl	EC50	17.2 µg ai/L 12.0 µg ai/L		PMRA 1265735 PMRA 1310349
		Diatom (*Navicula pelliculosa*)			6.5 µg ai/L		PMRA 1265734
Vascular Plants	Acute	Duck weed (*Lemna gibba*)	Carfentrazone-ethyl	14-d EC50 NOEC	5.9 µg ai/L 2.2 µg ai/L		PMRA 1265732 PMRA 1310349

Organism	Study type	Species	Test material	Endpoint	Value (effect)	Effect	Reference
Marine/Estuarine organisms							
Invertebrates	Acute	Mysid shrimp (*Mysidopsis bahia*)	Carfentrazone-ethyl	LC50 NOEC	1.16 mg ai/L 0.4 mg ai/L		PMRA 1265737
		Eastern oyster *(Crassostrea virginica)*		LC50 NOEC	2.05 mg ai/L 0.6 mg ai/L	shell deposition	PMRA 1265738
Fish	Acute	Tidewater silverside *(Menidia beryllina)*		LC50 NOEC	1.14 mg ai/L 0.44 mg ai/L	mortality	PMRA 1265739
Algae	Acute	*Skeletonema costatum*		EC50 NOEC	16 µg ai/L 10 µg ai/L		PMRA 1265733

Table 3 Screening level risk assessment for non-target terrestrial species other than birds and mammals

Organism	Exposure	Endpoint value	Applic. Rate (Turf)* (g ai/ha)	EEC[1]	RQ[2]
Invertebrates					
Earthworm	Acute contact	LC50 = 820 mg ai/kg soil	381	0.170 mg ai/kg soil	<0.1
Bee	Acute contact	LD50 = 27.9 µg ai/bee (31.25 kg ai/ha)[3]	176.6	0.1766 kg ai/ha	<0.1
Plants					
Plants	Seed germination	EC 25 = 10 g ai/ha	381	383 g ai/ha	**38**
	Vegetative vigour	EC 25 = 1 g ai/ha	176.6	176.6 g ai/ha	**177**

1 Environmental Exposure Concentration (Soil: calculated based on a soil density of 1.5 g/cm3, soil depth of 15 cm and the label rates taking into consideration dissipation between applications; Bee: maximum application rate.

2 Risk Quotient (RQ) = exposure/toxicity. RQ > 1 indicates exceedance of LOC (Level Of Concern).

3 Toxicity in µg/bee converted to the equivalent kg a.i./ha using a conversion factor of 1.12 (Atkins et al., 1981).

*Cumulative rate based on 4 applic. at 112 g ai/ha with 14 d interval soil t ½ 86 d, plant t1/2 10 d.

Atkins EL; Kellum D; Atkins KW. 1981. Reducing pesticide hazards to honey bees: mortality prediction techniques and integrated management techniques. Univ Calif, Div Agric Sci, Leaflet 2883. 22 pp.

Table 4 Screening level risk assessment for birds and mammals

Exposure	Toxicity endpoint (mg ai/kg bw/d)	Feeding Guild (food item)	EDE (mg ai/kg bw)	RQ
Small Bird (0.02 kg)				
Acute	225	Insectivore (small insects)	8.90	0.04
Reproduction	1000	Insectivore (small insects)	8.90	0.01
Medium Sized Bird (0.1 kg)				
Acute	225	Insectivore (small insects)	6.95	0.03
Reproduction	1000	Insectivore (small insects)	6.95	0.01
Large Sized Bird (1 kg)				
Acute	225	Insectivore (small insects)	7.25	0.03
Reproduction	1000	Insectivore (small insects)	7.25	0.01
Small Mammal (0.015 kg)				
Acute	500	Insectivore (small insects)	5.12	0.01
Reproduction	1500	Insectivore (small insects)	5.12	0.00
Medium Sized Mammal (0.035 kg)				
Acute	500	Herbivore (short grass)	16.04	0.03
Reproduction	1500	Herbivore (short grass)	16.04	0.01
Large Sized Mammal (1 kg)				
Acute	500	Herbivore (short grass)	8.57	0.02
Reproduction	1500	Herbivore (short grass)	8.57	0.01

Table 5 Risk assessment for terrestrial plants exposed to drift

Organism	Exposure	Endpoint value	Applic. Rate (Turf)*(g ai/ha)	Drift EEC**	RQ
Plants	Seed germination	EC 25 = 10 g ai/ha	381	22.9 g ai/ha	**2.3**
	Vegetative vigour	EC 25 = 1 g ai/ha	176.6	10.6	**11**

*Cumulative rate based on 4 applic. at 112 g ai/ha with 14 d interval; t ½ 86 d

**Based on drift of 6% for a default droplet size of medium (herbicides).

Table 6 Screening level risk assessment for aquatic organisms

Organism	Exposure	Species	Endpoint reported (mg ai/L)	Endpoint for RA* (mg ai/L)	Use Rate** (g ai/ha)	EEC*** (mg ai/L)	RQ[1]
Freshwater Species							
Invertebrates	Acute	*D. magna*	LC50 = 9.8	4.9	395	0.049	<0.1
	Chronic	*D. magna*	NOEC = 0.22	0.22			<0.1
Fish	Acute	Rainbow trout	LC50 = 1.6	0.16			0.3
	Chronic	Rainbow trout (Early Life Cycle)	NOEC = 0.016	0.016			**3**

Organism	Exposure	Species	Endpoint reported (mg ai/L)	Endpoint for RA* (mg ai/L)	Use Rate** (g ai/ha)	EEC*** (mg ai/L)	RQ[1]
Plants	Acute	Diatom	EC50 = 0.0065	0.00325			**15**
	Acute	Duckweed	EC50 = 0.0059	0.00295			**16**
Amphibian	Acute	Rainbow trout (surrogate)	LC50 = 1.6	0.16		0.26	**1.6**
	Chronic	Fish Early Life Cycle (surrogate)	NOEC = 0.016	0.016			**16**
Estuarine and Marine Species							
Invertebrates	Acute	Mysid shrimp	LC50 = 1.16	0.58	395	0.049	<0.1
Fish	Acute	Tidewater silverside	LC50 = 1.1	0.11			0.4
Plants	Acute	Algae	EC50 = 0.016	0.008			**6**

*Endpoints used in the acute exposure risk assessment (RA) are derived by dividing the EC50 or LC50 from the appropriate laboratory study by a factor of two (2) for aquatic invertebrates and plants, and by a factor of ten (10) for fish and amphibians.

**Cumulative rate based on 4appl. (112 g ai/ha, 14 d interval; $t_{1/2}$ 112 d)

***EEC based on a 15 cm water body depth for amphibians and a 80 cm water depth for all other aquatic organisms.

Table 7 Refined risk assessment for aquatic organisms

Organism	Exposure	Toxicity end point (mg ai/L)	Use Rate* (g ai/ha)	Drift EEC** (mg ai/L)	RQ
Amphibians	Acute	0.16	395	0.016	0.1
	Chronic	0.016			**1**
Fish	Chronic	0.016		0.003	**1.9**
Freshwater algae	Acute	0.00325			0.9
Vascular plants	Acute	0.00295			**1**
Marine algae	Acute	0.008			0.4

*Cumulative rate based on 4 appl. (112 g ai/ha, 14 d interval; $t_{1/2}$ 112 d)

**Based on drift of 6% for a default droplet size of medium (herbicides).

Table 8 Risk assessment for aquatic organisms exposed to predicted run-off

Toxicity Endpoint	EEC* [µg ai/L]	Endpoint [µg ai/L]	RQ
Amphibians			
Chronic	11	16	0.7
Fish			
Chronic	3.1	16	0.2
Freshwater Alga			
Acute	3.3	3.25	**1**
Marine/Estuarine Alga			
Acute	3.3	8	0.4
Freshwater Vascular Plants			
Acute	3.3	2.95	**1.1**
*90th percentile of peak and 21d runoff values for acute and chronic exposure, respectively			

Table 9 Toxic Substances Management Policy considerations-comparison to TSMP Track 1 Criteria

TSMP Track 1 Criteria	TSMP Track 1 Criterion value		Active Ingredient Endpoints	Transformation Products Endpoints
Toxic or toxic equivalent as defined by the *Canadian Environmental Protection Act*[1]	Yes			
Predominantly anthropogenic[2]	Yes			
Persistence[3]:	Soil	Half-life ≥ 182 d	Half-life = 1.2 d	Half-life = 86 d
	Water	Half-life ≥ 182 d	Half-life = 1.3	Half-life = 89
	Sediment	Half-life ≥ 365 d	Half-life	
	Air	Half-life ≥ 2 d	Half-life <1 d (phototransformation)	

TSMP Track 1 Criteria	TSMP Track 1 Criterion value	Active Ingredient Endpoints	Transformation Products Endpoints
Bioaccumulation[4]	Log $K_{OW} \geq 5$	3.36	
	BCF $\geq$ 5000	not available	
	BAF $\geq$ 5000	not available	
Is the chemical a TSMP Track 1 substance (all four criteria must be met)?		No, does not meet TSMP Track 1 criteria.	No, does not meet TSMP Track 1 criteria.

[1]All pesticides will be considered toxic or toxic equivalent for the purpose of initially assessing a pesticide against the TSMP criteria. Assessment of the toxicity criterion may be refined if required (i.e., all other TSMP criteria are met).

[2]The policy considers a substance "predominantly anthropogenic" if, based on expert judgement, its concentration in the environment medium is largely due to human activity, rather than to natural sources or releases.

[3] If the pesticide and/or the transformation product(s) meet one persistence criterion identified for one media (soil, water, sediment or air) than the criterion for persistence is considered to be met.

[4]Field data (e.g., BAFs) are preferred over laboratory data (e.g., BCFs) which, in turn, are preferred over chemical properties (e.g., log K_{OW}).

Appendix II Carfentrazone-ethyl Aquatic Ecoscenario Assessment

1.0 Introduction

The following sections review the estimated environmental concentrations (EECs) of carfentrazone ethyl resulting from water modelling and the available water monitoring data with respect to environmental exposure and drinking water.

Carfentrazone-ethyl transforms quickly to carfentrazone chloropropionic acid, and from there to several longer lived compounds. The modelled compound discussed here is the chloropropionic acid. Because carfentrazone-ethyl transforms quickly, the transformation rates used for modelling represent the rate of transformation of carfentrazone-ethyl and chloropropionic acid combined. The application rate modelled was adjusted for the lower molecular weight of the chloropropionic acid using the adjustment factor of 0.932 (384.1 (molecular weight of chloropropionic acid) over 412.2 (molecular weight of Carfentrazone ethyl)). Therefore the rate used in the modelling is 4 applications of 104.4 g ai/ha at the interval of 14 days.

2.0 Modelling Estimates

2.1 Application Information and Model Inputs

Carfentrazone-ethyl is an herbicide used on a variety of crops. The maximum annual application rate is for use on golf course greens and tees as well as sod farms for production of professional turf (bentgrass), 4 applications of 0.112 kg a.i./ha, at 14-day intervals. Application information and the main environmental fate characteristics used in the models are summarized in Table 1.

Table 1 Major groundwater and surface water model inputs for Level 1 assessment of carfentrazone ethyl and chloropropionic acid combined residue

Type of Input	Parameter	Value
Application Information	Crop(s) to be treated	golf course greens and tees as well as sod farms
	Maximum allowable application rate per year (g a.i./ha)	417.6 molecular ratio adjusted using 448 for parent
	Maximum rate each application (g a.i./ha)	104.4 molecular ratio adjusted using 112 for parent
	Maximum number of applications per year	4
	Minimum interval between applications (days)	14
	Method of application	Ground foliar
Environmental Fate Characteristics	Hydrolysis half-life at pH 7 (days)	Stable
	Photolysis half-life in water (days)	10.4
	Adsorption K_{OC} (mL/g)	14
	Aerobic soil biotransformation half-life	95

Type of Input	Parameter	Value
	(days)	
	Aerobic aquatic biotransformation half-life (days)	108
	Anaerobic aquatic biotransformation half-life (days)	190

2.2 Aquatic Ecoscenario Assessment: Level 1 Modelling

For Level 1 aquatic ecoscenario assessment, estimated environmental concentrations (EECs) of carfentrazone-ethyl and chloropropionic acid combined residue from runoff into a receiving water body were simulated using the PRZM/EXAMS models. The PRZM/EXAMS models simulate pesticide runoff from a treated field into an adjacent water body and the fate of a pesticide within that water body. For the Level 1 assessment, the water body consists of a 1 ha wetland with an average depth of 0.8 m and a drainage area of 10 ha. A seasonal water body was also used to assess the risk to amphibians, as a risk was identified at the screening level. This water body is essentially a scaled down version of the permanent water body noted above, but having a water depth of 0.15 m.

Five standard regional scenarios were modelled to represent different regions of Canada. Fourteen initial application dates between October and March were modelled in BC. Eleven initial application dates between May and October were modelled in rest of Canada Table 1 lists the application information and the main environmental fate characteristics used in the simulations. The EECs are for the portion of the pesticide that enters the water body via runoff only; deposition from spray drift is not included. The models were run for 50 years for all scenarios.

The EECs are calculated from the model output from each run as follows. For each year of the simulation, PRZM/EXAMS calculates peak (or daily maximum) and time-averaged concentrations. The time-averaged concentrations are calculated by averaging the daily concentrations over five time periods (96-hour, 21-day, 60-day, 90-day, and 1 year). The 90^{th} percentiles over each averaging period are reported as the EECs for that period. The largest EECs of all selected runs of a given use pattern/regional scenario are reported in Table 2.

Table 2 **Level 1 aquatic ecoscenario modelling EECs (μg a.i./L) for carfentrazone ethyl and chloropropionic acid combined residue in a water body 0.8 m deep, excluding spray drift**

Region	EEC (μg a.i./L)					
	Peak	96-hour	21-day	60-day	90-day	Yearly
In 80 cm water body						
BC	3.3	3.3	3.1	3.0	2.4	1.6
Prairie region	3.0	3.0	2.8	2.6	2.4	1.6
ON	3.1	3.1	3.1	2.9	2.8	1.6
QC	2.3	2.3	2.1	1.9	1.8	1.0
Atlantic region	2.9	2.8	2.7	2.5	2.4	1.4
In 15 cm water body						
BC	14	13	11	9.0	7.9	3.3
Prairie region	12	11	9.4	8.1	7.5	4.0
ON	11	11	8.9	7.4	7.2	3.8
QC	9.4	9.0	8.1	6.7	5.8	2.4
Atlantic region	10	9.9	8.3	6.6	6.3	3.4

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